MAPLETON CITY WELL SOURCE PROTECTION PLAN
PROJECT ID: CEEN-2019CPST-014

by

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A Capstone Project Final Report

Submitted to

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Department of Civil and Environmental Engineering
Brigham Young University

April 13, 2020

Executive Summary

PROJECT TITLE: MAPLETON CITY WELL SOURCE PROTECTION PLAN
PROJECT ID: CEEn-2018CPST-014
PROJECT SPONSOR: MAPLETON CITY PUBLIC WORKS
TEAM NAME: TJ^2

Mapleton City has 4 culinary water wells in operation. The state Division of Drinking Water (DDW) requires that each public drinking water system file a source protection plan for each culinary water source. The source protection plans in Mapleton need an update.

In accordance with DDW rules, TJ^2 has created these source protection plan that will be simple and effective in helping the City of Mapleton maintain a current and code-compliant source protection plan. To do this TJ^2 created a groundwater model, created geographic information system (GIS) maps, and created editable source protection plans.

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Introduction

The Utah State Department of Drinking Water requires municipalities to submit Ground Water Source Protection Plans for each source of groundwater used in culinary water systems, and these plans are to be updated on a regular 6-year cycle. The existing plans outdate the current Public Works Department management so the plans need to be reviewed and a new system devised to readily update the documents as changes to the source conditions necessitate changes to the plans.

The plans consists of several parts, including a map showing a delineation of protection zones and points of possible contamination. The plan also includes a catalogue of all possible contamination sources with an assessment of risk and plans for control/remediation. The plan is based around various protection zones for each water source that are determined using a model of the aquifer and groundwater movement. TJ^2 has analyzed the protection zones using a water model, making necessary changes to the previous model. Using the protection zones around each source, TJ^2 has created and updated GIS maps documenting the protection zones and potential contamination sources. Using the GIS maps, water model, and previous plans, TJ^2 has created new plans for each water source.

Schedule

TJ^2 met weekly and coordinated with Mapleton City to complete the project. The following is a list of tasks that was completed and an estimated date of when they were completed:

- Project launch, September 2019.
- Review of the Ground Water Source Protection Plan requirements from the DDW, October 2019.
- Review of previous reports and model, January 2020.
- Created ground water model, March 2020.
- Created GIS maps of protection zones and potential contamination sources, April 2020.
- Created editable plans, April 2020.
- Presentation and poster, April 2020.

Assumptions & Limitations

The project is easiest to review when divided into three sections. The water model, GIS maps, and plans are each reviewed in the following list:

- Water Model
  - Placing well locations is extremely inaccurate in WhAEM as points are placed on a map with no regard to geographical coordinates.
  - The model would not allow for exact coordinates to be placed and therefore had to be placed on the map through "eye balling" the location.
  - There are no Topographic maps that can be imported into the model. This made the waterflow difficult as the city is placed right up against a mountain. Because of this, it was assumed through discussion, the best angle to have the protection zones would be 155 Degrees. This made the water run Northwest which is relatively perpendicular to the mountain slopes.
    - Information of waterflow direction determined through USGS 1995 report cited below
      - Hydrology and Simulation of Ground-Water Flow in Southern Utah Valley and Goshen Valley, Utah. Technical Publication No. 111 State of Utah, 1995. Department of Natural Resources. by L.E. Brooks and B.J. Stolp.
  - Hydraulic conductivity of the wells was determined by using a MODFLOW program. This program gave average K values in the area. Two wells were in one hydraulic conductivity while the other two were in another. The program was unable to simultaneously run the two hydraulic conductivities. Therefore, we used the greatest of the calculated K values of 66 ft/day on both wells. This would make the wells of Crowd Canyon and Westwood more conservatively based.
  - The model would only run the calculation based on the view area on the computer. If zoomed in, all aspects of the model not seen would not be displayed on the map. This included truncating the well zones. The protection areas would also change slightly in width depending on the how closely zoomed in or out you are.
  - The program does not allow you to zoom in and place the points for the protection zones. The points must be placed from far out in order to have sufficient points to capture the protection zones. Because of this, some of the delineated protection zones have some overlap between the Zones 2, 3 and 4.
  - The depth and elevations of the aquifer used in the model were assumed to be correct from previously done reports.
- GIS Maps
  - GIS date for the well locations provided by Mapleton City would not import correctly so we used information from the State Division of Water Rights cross referenced with Mapleton's information for accuracy. For the Crowd Canyon well,

it did not appear that data existed in the file so the placement was done manually, using the visual of the wellhouse on the basemap as a guide.

- In one location, a monitoring well near to the Crowd Canyon production well, we were able to learn of the well's existence through the previous protection plans but it did not appear as expected. Looking at the point in the State Water Rights online interactive map had several logs with various water rights numbers, but the corresponding coordinates in the downloaded data pointed to other locations. The Division of Water Right's information had a privately owned well at the approximate location and distance from the city well so it was assumed these wells were the same.
- We were unable to obtain an actual comprehensive list of septic tanks in Mapleton so we drew information from a list of Mapleton residents that were not connected to the city sewer system as of November, 2019. Some of the provided addresses appeared to be undeveloped/uninhabited using Google Earth/Street View but were included to have a more conservative list of possible sources of contamination. In some locations there were two separate resident entry listed for the same address. It was assumed that these instances constituted one septic tank and only one set of names was listed. When this occurred, one resident entry had a "+" next to the name, so the other was listed.
- The two protection plans created in 2019 included information on the city storm drain system and mapped storm drain sumps, catch basins and pretreatment sumps with catch basins. The information provided by Mapleton City were shapefiles of storm inlets and manholes. It was assumed that inlets were equivalent to catch basins. The manhole information was brought into GIS file but was not accounted for in the protection plans was it was assumed that these did not have sumps. Beyond these files we did not have detailed information on where sump locations may be.
- Sewer pipes are listed by the state as a source of possible contamination but we did not receive any information on these to incorporate into the plans.
- One previous report cited two specific animal pastures within a well's protection Zones. This information was brought into our GIS file but we did not have any specific information beyond this as to where there may be animals kept in other wells' protection zones other than points plotted on a map. It is assumed that Mapleton City can update this information as desired. For the time being, the Carnesecca and Westwood well protection plans have animal pastures listed in the same group with residential lots and states that residential lots are not mapped due to city ordinances preventing contamination.
- There was not specific data available for residential lots and to make any data would be done by hand and making many assumptions. No residential GIS data was included.
- Only PCSs within protection zones are supposed to be displayed on the maps. Due to software challenges, PCSs within and without the protections zones were displayed.
- State instructions say to overlay source protection information on a topographical map but previous plans had not done so. We followed this pattern and used a map

that more closely resembles what is used in GPS software. The maps are more detailed and usable than previous reports.

- As we were unable to place wellheads with reasonable accuracy in WhAEM, the protection zones had to be corrected once they were imported into ArcGIS. Additionally, though two locations were placed with reasonable accuracy in WhAEM, they mapped in different locations in ArcGIS. All four wells' protection zones were corrected using locations from the State Division of Water Rights and it was assumed that the protection zones would remain reasonably accurate due to the simplicity of the modeling methods that we employed.

- Plans
  - It was assumed that the majority of data received from RB&G, DDW, Cascade Water Resources, and Mapleton City was accurate.
  - Each plan was created by using the data from the previous plans. For example, the new Westwood Well plan used data from the 1997, 2001, 2005, 2013, and 2016 plans. Since the new plan was created in 2020 and the previous plan was created in 2016 there is an approximate 4 year gap of information missing. Due to the minimal change of potential contamination sources and protections plans with time, this gap of information is assumed to be negligible. The following is a list of each water source and the date when the most recent plan was submitted:
    - Crowd Canyon Well, 2019
    - Seal Well, 2019
    - Spring System, 2017
    - Carnesecca Well, 2016
    - Westwood Well, 2016
  - The most recent plans from Seal Well and Crowd Canyon Well were submitted to DDW in 2019 and are still being reviewed. Even though these plans have not been approved yet, they were used under the assumption that they would be approved, and thus contain reliable information.
  - Seal Well, Carnesecca Well, and Westwood Well all claim protected aquifer status due mainly to large clay layers that were confirmed during drilling the wells. This source of protection is questionable in their protection zones protruding into the mountains because of the many faults and change in geology going into the mountains.
  - The new plans only contain city newsletters up to and including December 2019.

Design, Analysis & Results

The groundwater source protection zones for each well were exported as shapefiles from WhAEM and brought into ArcGIS Pro to overlay with various layers portraying potential sources of contamination and other relevant information. Information was obtained from several sources and in various forms. Locations of wells and the city boundaries were obtained from state websites, the Division of Water Rights and the AGRC respectively. Additionally, septic tank information was obtained from the state, but the list originated with Mapleton City. Shapefiles for storm drain inlets and manholes were obtained from the City.

Information from Mapleton did not need to be further refined, but the state information contained vast amounts of data. The data was refined using Geoprocessing tools within ArcGIS as well as some manual deletion. The city's boundaries were found in a file with all Municipal boundaries in the state and it was a simple task to delete information for all other cities. The well data however included every point of diversion that the state had record of, including both surface and ground water rights. All water rights within Mapleton and surrounding area have a number starting with "51-" so all diversions outside of that range were removed. The data was further refined by removing all water rights that were not listed as "underground" or "spring." This proved to be an issue though as all but one of the springs that Mapleton uses for culinary water are listed as "surface" rights, so rework had to be done to bring this information back in. Once the data was refined down to a more workable number of entries, a polygon was used to delete many diversion points that were outside of our area of concern. The data could be further refined as desired as there are still points outside of Mapleton City that are down gradient of the city wells. From this list of diversions, each city well and the Serviceberry Spring were pulled out using the "Select" to make a separate layer for those water sources.

Because the possible septic tank locations were given in a list form, it was easiest to create points for each address using Google Earth Pro and exporting the set as a KML file. ArcGIS Pro has a specific function that was used to import the KML file as a layer. A similar process was used to plot the two animal pastures included in the map.

Due to functionality problems with WhAEM, as listed in the "Assumptions & Limitations" section of this report, the imported protection zones had to be corrected to the proper location. As all protection zones were imported as one layer, they were broken into individual sets of protection zones for each well using the "Select" tool. Using the well points likewise imported from WhAEM, the offset to the actual well locations obtained from the State was determined and the zones were moved accordingly to be within reasonable accuracy of the actual well locations. As Zone I is a 100-foot radius around each well, these were created using the "Buffer" tool using the set of City wells as an input. These were not plotted but are included in the GIS file. Dimensions of the protection zones were measured in this file.

Layouts were created for each well with its corresponding protection zones and copies were made for the various potential contamination sources that were to be mapped. Each requisite map was exported as a PDF to have a title and figure number added later (See Figure 1)

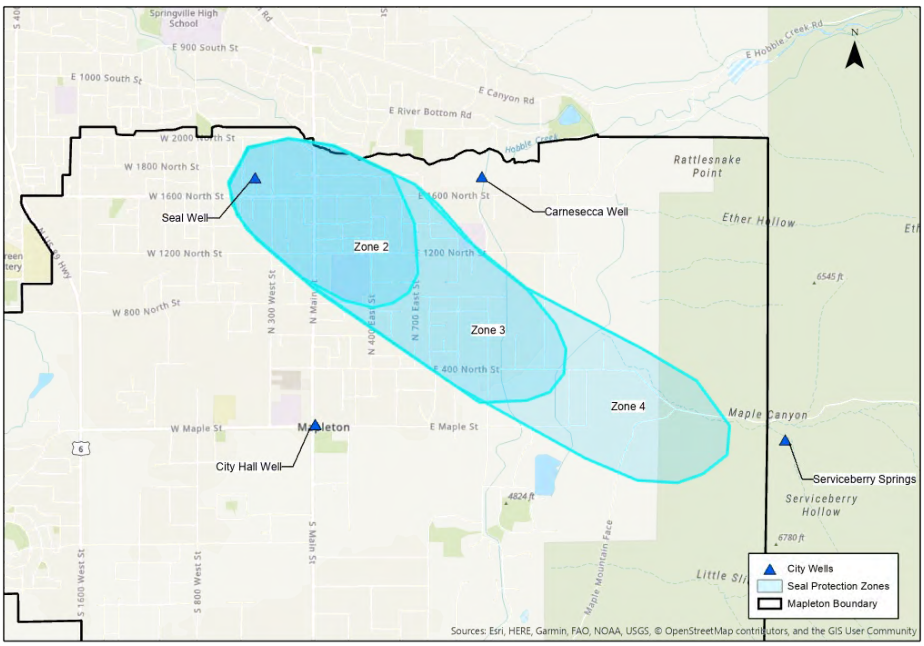

Figure 1: Seal Well Protection Zones

In order to create the plans all the previous plans were first obtained. Plans were obtained from RB&G, DDW, and Cascade Water Resources. Preliminary Evaluation Reports (PERs) because they are made before a well is drilled and work as a “best guess”. The 2019 Seal Well and Crowd Canyon Well plans were used, but they have not been approved by the DDW yet.

Using all of the aforementioned plans, a new plan was made for each water source. To do this information was copied from the most recent plan. Occasionally the most recent plan would simply state “No Changes”, in which case the information was copied from the next most recent report. Following this pattern provided most the information required. Further information about the Crowd Canyon Well was obtained from Cascade Water Resources. A rare few times information was still missing and had to be determined by TJ^2.

Lessons Learned

A challenge for approximately the first five months of the project was not fully understanding our project and what was expected of us. After meeting with our sponsor, we thought we understood the project and what we should do. As we began to dive into the work, we found that we were still unsure of what exactly we were supposed to do. In particular, we were confused after reaching out to the engineering firm that had previously compiled these plans for the city and they gave us the impression that they were doing what we had been assigned. Meeting with our project sponsor after this helped us to better establish what we needed to do. This experience is a lesson in communicating clear expectations and asking questions until the project is fully understood. It wasn't until the latter half of the project timeline that we were able to communicate with our sponsor effectively and establish clear expectations, and then the project really started to move forward.

Another challenge for approximately the first six months was starting to write the plans. Due to their large size and many requirements we felt overwhelmed and didn't know where to start. This experience taught us the lesson of digging in your heels and just getting started. It wasn't until we dived in that we started to understand the plans and learned how to write them.

A mistake for about the first half of the project was counting our in class hours as project time. Each week we would see that we had done, for example, 3 hours each. It was easy to feel like we were working in our project, but actually, we weren't hardly working on our project because half of that time was from in class discussions. We learned the lesson that working on something doesn't mean you're working effectively on the project. We had to work more and pay more attention to the progress on the project than on the number of hours we had done.

Closely related to the last lesson was one on budgeting time. Our initial estimation of how long the project would take was a gross underestimation (about ¼ of what it actually took). This teaches us the lesson of starting early and estimating well how long something will take. By working more early on in the project we would have sooner realized our gross underestimation, or by better initial planning we would have had a good starting estimation. We had to make up for this mistake by working a lot more than expected at the end of the project timeline.

We learned the lesson that it is best to set team expectations early. For some time, the work being done was unfairly distributed among the team members. One of the fixes we identified was to set a specific standard for each team member to achieve which in turn pushed us all to have the same goal in how much time we would spend on the project. Having set expectations helped us to better measure our efforts against each other to better distribute the load between each team member. This also showed the necessity of addressing problems as they present themselves and that a simple discussion can yield great dividends towards fixing a problem.

Conclusions

Over the past academic year, we have become well acquainted with the system the state of Utah has put in place to protect culinary groundwater sources and more specifically, how Mapleton City is protecting their water. In the review of numerous standards, previous reports, geologic properties and geographic data, we have learned much of the intricacy of engineering work and regulations. What may have seemed like a relatively straightforward project at first became an undertaking that required a keen eye for details and a comprehensive knowledge of engineering principles, computer programs and communication. As the specific application of this project is a small niche in the realm of engineering, our biggest lessons were in the process of taking a project from a simple concept to a comprehensive work with tangible deliverables.

Recommendations

In general, our biggest challenge was our struggle to have regular communication with the project sponsor. We made many attempts at contact but they continually seemed to yield no results for the first semester of the project and thus our work was delayed. We would recommend that the client set clear expectations and a schedule for communications in future projects.

Additional recommendations are listed below as they relate to the specific phases of our project:

- Water Model
  - Keep Information Updated
    - As demands of the wells change, update discharge rates
  - Only calculate the protection zones using Multiple Wellhead Protection Zone function on WhAEM. The program does not have the capability to effectively analyze individual trace particles due to elevation restraints with the mountains being right against the city.
- GIS Maps
  - Keep Information Updated
    - As the city pushes to move every house possible to the sewer system, update the GIS layer for septic tanks to reflect the decommissioned tanks.
    - As the city expands, the city will surely expand its storm drain system. Update with new drainage structures and add more specific information such as sump type.
    - If the city receives information on new wells that are installed, add this data to the Active Well layer.
    - We did not have data for depth and diameter of private wells as has been included in previous reports. It is recommended that this data is added if available.
  - Add data for other potential sources of contamination
    - There were some sets of data that we were unable to obtain in the time we had or just had overlooked earlier on. These include sewer pipes, underground storage tanks and a more comprehensive list of animal pastures, residential lots and agricultural fields. It is recommended that if information on residences, fields, and pastures that the city references earlier reports in reporting this information, possibly listing the count of such properties in Section 3.
    - Add other sources that may arise as a concern to the city, especially as development continues in the areas around Westwood and Crowd Canyon Wells. It is recommended that the city look over the list that the state provides on pages 24-26 of the Groundwater Source Protection User's Guide.
  - Implement Quality Control Measure
    - The data we used was so immense that there are likely inaccuracies. Review the data we have put together to find any deficiencies.

- Plans
  - Simplify
    - Submit all the reports at the same time for uniformity and efficiency.
    - Make Sections 4-11 universal. Most of the information could be copied in each report.
    - Section 11 only had to be done once. For this section, simply state that it has already been completed. Also, the second paragraph in the Annual Drinking Water Quality report fulfills section 11.
    - Briefly report on EBCo. In depth discussions are not needed anymore.
    - Don't add more contamination sources if Mapleton City is not going to do anything about them. For example, adding sewer lines to the report when the Utah Department of Water Quality isn't asking for them and Mapleton City is not going to change their behavior by adding them.
  - Remove
    - Remove in-depth discussions on small individual contamination sources. For example, don't report that a homeowner keeps sheep on his farm for two months during the year to help them give birth. Just report all the properties with farm animals on them at once.
    - Remove insignificant ordinances. For example, siting an ordinance that states 8 sheep = 1 animal unit.
    - Remove protection actions that Mapleton City is not using. For example: Does Mapleton City inspect Whiting campground every year on April 1st? Does Mapleton City use the record keeping forms at the end of each plan?
  - Obtain a list of active waivers from DDW and report them on future plans. Most the previous plans state that Mapleton City has waivers, but not what those waivers are.
  - Follow the spirit of the law. The DDW has very detailed requirements, but it is clear from previous reports that they ignore those requirements when it seems reasonable to do so.

Appendix A

Joel Smith, E.I.T.

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EDUCATION

Brigham Young University — **Anticipated Graduation**

- BS degree in Civil Engineering — Apr. 2021
- Anticipating MS degree in Structural Engineering — Apr. 2022
- Minors in Mathematics and Family Life
- 3.93 GPA

SKILLS

Hard Skills: AutoCAD, VBA, Excel, Report Writing, Concrete Testing, Soil Testing, Asphalt Testing, Bluebeam
Soft Skills: Cheerful, Ethical, Detailed, Teamwork, Confident, Adaptable, Planning, Managing Stress

INTERNSHIPS

Infinity Consultants — **May 2019 – Aug. 2019**
Field Technician — *Lehi, UT*

- Created a program in VBA that saved management 6 hours every week
- Performed concrete, soil density, and asphalt density tests in the field
- Conducted soil lab tests quickly to meet customer needs
- Trained new technician how to perform field tests

Terracon — **May 2018 – Aug. 2018**
Field Technician — *Salt Lake City, UT*

- Coded a spreadsheet in VBA that saved management 2 hours every week
- Composed 2 technical reports daily to document field testing
- Became ACI Grade 1 certified and performed concrete field tests

Pleasant Grove City — **May 2017 – Sept. 2017**
Engineer's Assistant — *Pleasant Grove, UT*

- Learned Bluebeam by analyzing plans to create bond estimates
- Aided city inspector by inspecting sidewalk, road, and street excavation repairs
- Saved time for staff engineers by resolving complaints from concerned citizens

Solcius — **Feb. 2016 – Aug. 2016**
CAD Designer — *Lindon, UT*

- Gained 400+ hours of work experience in AutoCAD LT
- Drafted solar plan sets faster than expected
- Programmed complex Excel formulas to automate structural calculations
- Improved my teamwork capabilities by being trained on two teams

PROJECTS

ASCE Steel Bridge — **Aug. 2016 – Apr. 2017**

- Proposed solutions for design challenges
- Collaborated with a team of students to construct the bridge

ASCE Concrete Canoe — **Sept. 2015 – Dec. 2015**

- Designed and tested different concrete mixtures
- Worked with a team of students to build the canoe

Taylor Petersen

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EDUCATION

Brigham Young University – Ira A Fulton College of Engineering **Aug 2016 - Present**
Bachelors of Civil Engineering *Provo, Utah*

WORK EXPERIENCE

Harrington Group Inc. **May 2018 - Present**
Fire Protection Engineering Consultant Intern *Duluth, Georgia*

- Reviewed the shop submittals of numerous large warehouses and buildings to ensure that compliance with building and fire codes was met
- Visited the construction sites of several warehouses to verify sprinkler installation conforms to code and witnessed the acceptance tests of fire pumps.
- Built a database using MS Excel that quickly and accurately assesses 1000+ different fire sprinkler protection schemes and their criteria, and reported in a manner to save all engineers immense time
- Created and analyzed sprinkler systems to help clients save money, yet not compromise the integrity of the system

BYU Traffic **Sept 2015 - Present**
Student Supervising Officer/Equipment Manager *Provo, Utah*

- Managed 20+ traffic officers in daily assignments and during special events around campus
- Organized and made the management of a large inventory of traffic directing equipment in a way that is both efficient and effective
- Analyzed the flow of traffic during large events to identify areas of congestion and effective ways to improve the flow of cars efficiently

Pointe Pest Control **May 2016 – Aug 2016**
Sale Representative *Provo, Utah*

- Generated $30,000+ of revenue for the company
- Learned consultative selling skills to identify opportunities, overcome objections and close sales
- Established Need, Value and Urgency of our product and services

VOLUNTEER EXPERIENCE

The Church of Jesus Christ of Latter-day Saints **Jul 2013 – July 2015**
Fulltime Representative *Houston, Texas*

- Employed goal-setting skills to optimize time during a 12-hour work day and 80+ hour work week
- Organized and led training meetings every week for up to 26 people during a 12-month period which resulted in increased productivity through the amount of contacts per week and appointments kept per week

SKILLS & INTERESTS

- Advanced Excel and computer skills
- HydraCalc
- Camping, Hiking, ATV riding, Fishing, Computers
- High School FIRST Robotics

JEFFERY BROWN

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EDUCATION

Brigham Young University-*Bachelor of Science Civil Engineering* December 2020
- Civil Engineering Major – Expected Graduation in 2021
  Provo, UT

WORK EXPERIENCE

HNTB – *Civil Engineer Intern* April 2018-Present
- Salt Lake International Airport Terminal Redevelopment Program
  Salt Lake, UT
  - Participate in drafting and design work for the UTA TRAX line and station, local utilities, pavement, etc.
  - Construction management working with material approvals and requests for information from the contractor.
- UDOT I-15 and Bangerter Projects
- Local IT Assistant

Vivint. – *Alarm Specialist* May 2017-April 2018
- Communicated and served customers in making and receiving over 2000 calls a month.
  Provo, UT
- Regularly assisted endangered customers in emergency situations by dispatching emergency services, reassuring them through continued conversation.
- Served as a New Hire Guide.
- Participated in a customer service Pilot Program to expand the service ability of our department.

Kneaders (Riverwoods) – *Cook* Aug 2016-May 2017
- Worked as a team member and partially responsible for cleaning and closing the store.
  Provo, UT

SKILLS AND ACCOMPLISHMENTS

Proficient in AutoCAD Civil 3D
Intermediate Experience in other AutoDesk Products – Revit, Fusion 360
Proficient in Microsoft Office Suite
VBA

Full-time Representative - The Church of Jesus Christ of Latter-day Saints Sept 2013-Sept 2015
Regularly contacted and taught individuals.